Original Article

Dimensional and morphological analysis of various rugae patterns in Kerala (South India) sample population: A cross-sectional study

Manickam Selvamani, Shilpa Hosallimath[1], Madhushankari[1], Praveen Shivappa Basandi[1], Andamuthu Yamunadevi[2]

Department of Oral and Maxillofacial Pathology and Microbiology, Mahe Institute of Dental Science and Hospital, Mahe, Union Territory of Puducherry, [1]Department of Oral and Maxillofacial Pathology and Microbiology, College of Dental Sciences and Hospital, Davangere, Karnataka, [2]Department of Oral and Maxillofacial Pathology and Microbiology, Vivekanandha Dental College for Women, Elayampalayam, Namakkal, Tamil Nadu, India

Address for correspondence:
Dr. M. Selvamani, Department of Oral and Maxillofacial Pathology and Microbiology, Mahe Institute of Dental Science and Hospital, Mahe, Union Territory of Puducherry, India.
E-mail: manioralpath@gmail.com

Abstract

Background: Analysis of palatal rugae patterns, which are similar to fingerprints, is one of the techniques used in forensic sciences for human identification. As palatal rugae patterns are genetically determined, they can also be used in population differentiation and gender determination. Hence, we aimed to record the distribution of the predominant rugae pattern in Kerala population. **Materials and Methods:** A total of 100 maxillary study models (40 males and 60 females) recorded from Kerala population within the age group of 17-25 years were analyzed. The dental casts were examined for the interpretation of the total number, length, shape, location and unification of rugae. Chi-square test and unpaired *t*-test were employed for statistical analysis. **Result:** The total number of rugae was significantly ($P < 0.001$) greater in females than males. Regarding the shape, wavy pattern predominated in both males and females, followed by curve, straight, divergent, convergent and circular pattern. Circular pattern was more in males than females. The rugae patterns were located more in between mesial aspect of first premolar to mesial aspect of second premolar. **Conclusion:** The palatal rugae and their features of an individual may be considered as a reliable guide for identification purpose, provided antemortem casts are available. Nevertheless, gender differentiation is evident in terms of number and shape of rugae.

Key words: Forensic sciences, palatal rugae, human identification

INTRODUCTION

Forensic odontology is a speciality in dentistry which occupies a primary place within the total spectrum of methods applied to medico-legal identification.[1] Identification of the deceased becomes challenging during mass disasters and is a prime requisite for certification of death and personal, social and legal reasons. DNA, fingerprint and dental record comparisons are the most commonly used scientific methods of forensic identification.[2] Constraints to the use of fingerprints occur in situations where the hands are charred or mutilated. Though teeth are more durable, it is however not practical to employ them in identifying the edentulous persons. A useful method of human identification in these circumstances is by examining the palatal rugae pattern (palatal rugoscopy).[3]

Access this article online	
Quick Response Code:	Website: www.jnsbm.org
	DOI: 10.4103/0976-9668.159985

Palatal rugae are the ridges present on the anterior part of the palatal mucosa on either side of the median palatal raphae and behind the incisive papilla.[4] They are highly individualistic, and not identical even among twins.[5] They are also stable and consistent in shape throughout the life following completion of growth. Rugae are well protected by the lip, cheek, tongue, buccal pad of fat and teeth. Hence,

it can resist the incidents of fire and high-impact trauma and can also resist decomposition up to 7 days.[3,6,7] These patterns are analyzed in various population and found to be differing among people of different geographical locations and gender.[1,8-11] Thus, the objective of the present study was to record the distribution of the predominant rugae pattern (palatal rugae number, shape, length, unification and location) in Kerala population and to compare the distribution of these parameters between males and females to know if gender differentiation is possible.

MATERIALS AND METHODS

The study sample consisted of 100 students (n = 100) studying in College of Dental Sciences, Davangere, within the age group of 17–25 years, of which 60 were females and 40 were males. All of them belonged to the same geographical population, Kerala and were healthy, free of congenital abnormalities (e.g., cleft palate), inflammation, trauma, orthodontic treatment or any other palatal pathology. The subjects with a history of palatal surgery, loss of teeth were excluded. The purpose of this study was explained to the subjects and after obtaining informed consent from them, the impression of their maxillary arch was recorded using alginate and models were prepared by pouring dental stone in the impressions. The rugae pattern were highlighted by a blue marker pen on the cast [Figure 1] and the method of rugae analysis used in this study was based on the classification given by Thomas and Kotze [Figure 2].[12] For location analysis, classification given by Hermosilla *et al.*[13] was used [Figure 3]. All the parameters were analyzed by two independent observers. Measurements for length were made directly from the cast using digital slide calipers.

Statistical analysis

The data collected were statically analyzed using SPSS version 17.0 software Chicago, USA. Chi-square test was used for analysis and association of length, shape, unification and location in males and females while unpaired *t*-test was employed to compare the number of rugae.

RESULTS

The total number of rugae were more in females than males, which was statistically significant ($P \leq 0.001$, significant) [Table 1]. Unification for palatal rugae did not show any significant difference between males and females and diverging pattern constituted more percentage than converging pattern [Table 2]. On observing the length of rugae, primary rugae were predominant compared to secondary and fragmentary in both males and females [Table 3] and no significant gender differentiation was noted (P = 0.82). Rugae were found predominantly in location D followed by E, C, and B both in males and females [Table 4]. On observing rugae shape, we found wavy pattern to be more common, followed by curve and straight pattern in both males and females (Chi-square = 11.37, P = 0.05) [Table 5]. Circular pattern was significantly more in males as compared to females, aiding in gender differentiation.

Figure 1: Rugae pattern analysis using dental cast of subjects

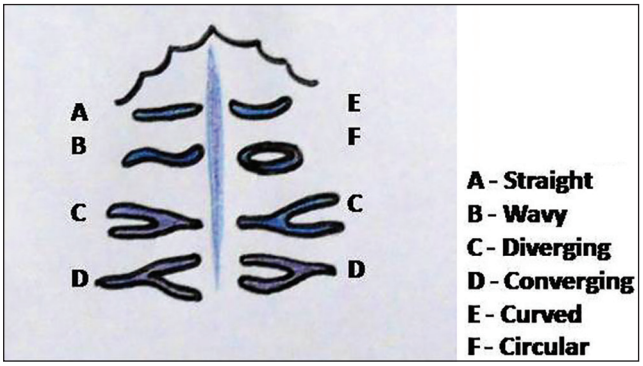

Figure 2: Pictorial representation of the analysis of various shapes of palatal rugae (according to Thomas and Kotze)[12]

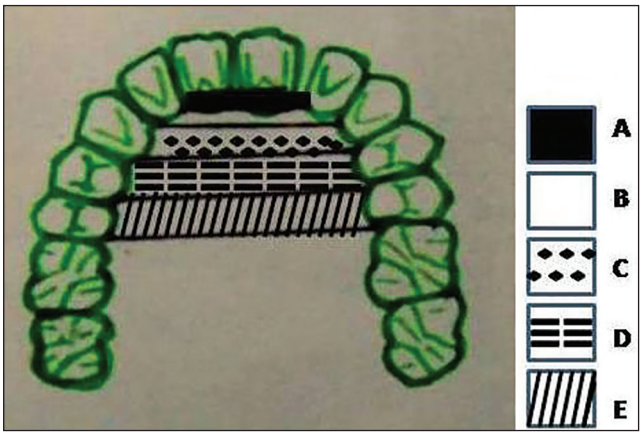

Figure 3: Pictorial representation of the analysis of location of palatal rugae (according to Hermosilla *et al.*[13])

DISCUSSION

The potential use of palatal rugoscopy (palatoscopy, rugoscopy)[14-16] in forensic identification has advantages because of their low utilization cost, simplicity, and reliability. Palatal rugae patterns are sufficiently characteristic to discriminate between individuals[1,3,5,8,17] and are also stable under severe burn cases, unaltered by chemicals like nicotine, ethanol, acetyl salicylate[8] and physical irritants. They are applicable to edentulous patients and are proved to be the same before and after orthodontic treatment[18] and remains stable after completion of growth[8] thus emerging to be one of the reliable applications in forensic science. Palatal rugae patterns show variations with racial and geographical variations and are applicable for gender differentiation.[1,8,9,11,13,19-22] In spite of these advantages of rugoscopy, the scale of reliability on this technique is unclear, with some studies contradicting their utility in forensic medicine.[15,16,18,23-26] Moreover availability of ante mortem casts or any records like photographs is must for identification using palatoscopy.

In the present study, the number of palatal rugae was slightly more in females (mean = 10.18) than males (mean = 9.9), which is consistent with other reports from other populations.[5,8,9,13,20,22,24,27] Among the unification patterns, diverging pattern was observed more in both males and females than converging pattern, which is consistent with previous studies done on Kerala population.[9,28] In contrast, statistical analysis for assessing sex differences in the rugae shapes showed significant difference in unification type in three South Indian population studies.[8,20,11]

Depending on the length of the palatal rugae, they were classified into primary, secondary and fragmentary rugae and on analysis; their distribution was almost equal between males and females. Primary rugae (82% in males and 81% in females) were observed predominantly, followed by secondary rugae (12% in both gender) and fragmentary rugae (6% in males and 7% in females) and results were similar to previous reports.[1,9,24,28]

Considering the location of rugae patterns, in both males and females, rugae were found predominantly in the D region, between mesial aspect of first premolar and mesial aspect of second premolar, (45% in males and 42% in females), followed by E (29% in males and 32% in females), C (23% in males and 24% in females), and B (3% in males and 2% in males). The region A is not involved by any of the rugae examined and no rugae were found beyond E region. The results did not show significant gender differentiation ($P = 0.44$). Only few studies have analyzed the location[14] wherein more rugae were found in the E region (between mesial aspect of second premolar to distal aspect of second premolar) followed by D region.

On observing the rugae shape, we found wavy pattern to be the most common in both the genders, followed by curve and straight pattern. Circular pattern was very few in number and was significantly ($P = 0.05$) more in males than females and hence can be utilized as a valuable parameter for gender determination. Our results are again consistent with other reports,[9,15,28,11] however some have reported a predominance of straight patterns.[20,29] Thus, difference in predominant shape was noted in different geographical regions within India and discrete variables

Table 1: Analysis of total number of palatal rugae in Kerala population

Sex	Total	Mean	*P*
Males	395	9.9±1.9	
Females	611	10.18±2.1	<0.001 (by unpaired *t*-test)

Table 2: Analysis of unification pattern of palatal rugae in Kerala population

Sex	Total	Diverging (%)	Converging (%)
Males	35	24 (68.5)	11 (31.4)
Female	45	33 (73.3)	12 (26.7)

Chi-square = 1.69, *P* = 0.19, Nonsignificant

Table 3: Analysis of length of palatal rugae in Kerala population

Sex	Total	Primary (%)	Secondary (%)	Fragmentary (%)
Males	395	324 (82)	49 (12)	22 (6)
Females	611	496 (81)	75 (12)	40 (7)

Chi-square = 0.40, *P* = 0.82, Nonsignificant

Table 4: Analysis of location of palatal rugae in Kerala population

Sex	Total	B (%)	C (%)	D (%)	E (%)
Males	395	11 (3)	94 (23)	175 (45)	115 (29)
Females	611	10 (2)	145 (24)	250 (42)	195 (32)

Chi-square = 2.69, *P* = 0.44, Nonsignificant

Table 5: Analysis of different shapes of palatal rugae in Kerala population

Sex	Total	Curve (%)	Wavy (%)	Straight (%)	Circular (%)	Conver (%)	Diver (%)
Males	395	113 (29)	177 (45)	65 (16)	5 (1)	11 (3)	24 (6.7)
Females	611	215 (35)	230 (38)	119 (19)	2 (0.3)	12 (2)	33 (5.45)

Chi-square = 11.37, *P* = 0.05, Significant

such as rugae shape can be better adopted for population differentiation and gender discrimination, rather than considering continuous variables like rugae length, as previously suggested.[29]

All the rugae patterns analyzed in our study were unique to each subject and did not show similarity with any other persons, reflecting the individuality of these patterns. Beyond the foresaid limitations on rugoscopy, the individuality and uniqueness of palatal rugae pattern is highly promising.[5] To improve the specificity and sensitivity of palatoscopy on population discrimination and gender identification, the subject is being investigated with utility of advanced statistical analysis.[8,11]

CONCLUSION

In the Kerala population, among the palatal rugae, the primary rugae are more in number, wavy pattern predominates in shape and more number of rugae is located in between mesial aspect of first premolar to mesial aspect of second premolar. The mean number and shape of rugae reveal significant differences between the two genders, which may be employed for gender determination. They are observed to be highly unique to an individual similar to fingerprint patterns, and with provision of ante mortem cast, they can be used for person identification.

REFERENCES

1. Saraf A, Bedia S, Indurkar A, Degwekar S, Bhowate R. Rugae patterns as an adjunct to sex differentiation in forensic identification. J Forensic Odontostomatol 2011;29:14-9.
2. Whittaker DK. An introduction to forensic dentistry. Quintessence Int 1994;25:723-30.
3. Acharya AB, Sivapathasundaram B. Forensic odontology. In: Rajendran R, Sivapathasundaram B, editors. Shafer's Textbook of Oral Pathology. 5th ed. New Delhi, India: Elsevier Publications; 2007. p. 886.
4. Snell RS. Clinical Anatomy by Regions. 8th ed. Philadelphia: Lippincott Williams and Wilkins; 2008.
5. Indira A, Gupta M, David MP. Usefullness of palatal rugae patterns in establishing identity: Preliminary results from Bengaluru city, India. J Forensic Dent Sci 2012;4:2-5.
6. Muthusubramanian M, Limson KS, Julian R. Analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition. J Forensic Odontostomatol 2005;23:26-9.
7. Segelinck SL, Goldstein L. Forensic application of palatal rugae in dental identification. Forensic Exam Spring 2005;14:44-7.
8. Bharath ST, Kumar GR, Dhanapal R, Saraswathi T. Sex determination by discriminant function analysis of palatal rugae from a population of coastal Andhra. J Forensic Dent Sci 2011;3:58-62.
9. Surekha R, Anila K, Reddy VS, Hunasgi S, Ravikumar S, Ramesh N. Assessment of palatal rugae patterns in Manipuri and Kerala population. J Forensic Dent Sci 2012;4:93-6.
10. Limson KS, Julian R. Computerized recording of the palatal rugae pattern and an evaluation of its application in forensic identification. J Forensic Odontostomatol 2004;22:1-4.
11. Shanmugam S, Anuthama K, Shaikh H, Murali K, Suresan V, Nisharudeen K, *et al.* Palatal rugae in population differentiation between South and North Indians: A discriminant function analysis. J Forensic Dent Sci 2012;4:75-9.
12. Thomas CJ, Kotze TJ. The palatal rugae pattern: A new classification. J Dent Assoc S Afr 1983;38:153-7.
13. Hermosilla VV, San Pedro VJ, Cantín LM, Suazo GI. Palatal rugae: Systematic analysis of its shape and dimensions for use in human identification. Int J Morphol 2009;27:819-25.
14. Pueyo VM, Garrido BR, Sánchez JS. Odontología legaly forense, Masson, Barcelona. 1994;23:277-92.
15. Sumathi MK, Balaji N, Vezhavendhan N, Sathish KG, Shanthi V. Palatoscopy among Pondicherry population. J Sci Dent 2011;1:16-8.
16. AbouEI-Foots MM, HemmaEI-Sharkawy GZ. A study of palatal rugae pattern (rugoscopy) in an Egyptian population. Egypt Dent J 1998;44:3177-84.
17. English WR, Robison SF, Summitt JB, Oesterle LJ, Brannon RB, Morlang WM. Individuality of human palatal rugae. J Forensic Sci 1988;33:718-26.
18. Pateria AH, Thakkar K. Palatal rugae, a stable landmark – A comparison between pre and post orthodontic patients. Int J Dent Clin 2011;3:9-12.
19. Mohammed RB, Rao TH, Rani S, Chowdary MS, Prasanthi B, Pakki SK. Analysis of various rugae patterns among coastal Andhra (South Indian) population: Digitized method. Oral Maxillofac Pathol J 2014;5:418-22.
20. Madhan Kumar S, Natarajan S, Maheshwari U, Kumar VA, Veeravalli PT, Banu F. Palatal rugae pattern for gender identification among selected student population in Chennai, India. J Sci Res Rep 2013;2:491-6.
21. Shetty M, Premalatha K. Study of palatal rugae pattern among the student population in Mangalore. J Indian Acad Forensic Med 2011;33:112-5.
22. Shubha C, Sujatha GP, Ashok L, Santhosh CS. A study of palatal rugae pattern among North and South Indian population of Davanagere city. J Indian Acad Forensic Med 2013;35:219-2.
23. Jawad IA. Comparison of rugae pattern between dentate and edentulous patients in Iraqi sample. Al Rafidain Dent J 2010;10:265-71.
24. Kapali S, Townsend G, Richards L, Parish T. Palatal rugae patterns in Australian aborigines and Caucasians. Aust Dent J 1997;42:129-33.
25. Shukla D, Chowdhry A, Bablani D, Jain P, Thapar R. Establishing the reliability of palatal rugae pattern in individual identification (following orthodontic treatment). J Forensic Odontostomatol 2011;29:20-9.
26. Lysell L. Plicae palatinae transversae and papilla incisiva in man; a morphologic and genetic study. Acta Odontol Scand 1955;13 Suppl 18:5-137.
27. Manjunath S. Palatal rugae patterns among the Indians at Manipal, India. J Pharm Biomed Sci 2012;20:10.
28. Paliwal A, Wanjari S, Parwani R. Palatal rugoscopy: Establishing identity. J Forensic Dent Sci 2010;2:27-31.
29. Nayak P, Acharya AB, Padmini AT, Kaveri H. Differences in the palatal rugae shape in two populations of India. Arch Oral Biol 2007;52:977-82.

How to cite this article: Selvamani M, Hosallimath S, Madhushankari, Basandi PS, Yamunadevi A. Dimensional and morphological analysis of various rugae patterns in Kerala (South India) sample population: A cross-sectional study. J Nat Sc Biol Med 2015;6:306-9.

Source of Support: Nil. **Conflict of Interest:** None declared.